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### APPENDIX O: POLLUTION PREVENTION

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## **APPENDIX O: POLLUTION PREVENTION**

### **O.1 INTRODUCTION**

Pollution prevention includes practices that reduce the use of hazardous materials, energy, water, and other resources along with practices that protect natural resources through conservation, more efficient use, and recycling. Pollution prevention encompasses source reduction, waste minimization, and energy, water, and natural resource conservation programs and activities. Lawrence Livermore National Laboratory (LLNL) programs address this broad scope of pollution prevention.

This appendix discusses pollution prevention programs and activities of LLNL. Section O.2 presents the regulatory setting for these programs. Section O.3 discusses the history of pollution prevention, energy efficiency, and water conservation at LLNL and introduces the site organizations that lead and facilitate the programs. Section O.4 includes descriptions of various pollution prevention, water conservation, and energy efficiency activities and projects recently completed and ongoing. Section O.5 discusses LLNL research and development projects that have implications and applications for pollution prevention and energy conservation for government, businesses, and individuals.

### **O.2 REGULATORY SETTING**

LLNL operations regarding pollution prevention, water conservation, and energy efficiency are conducted pursuant to Executive Orders, U.S. Department of Energy (DOE) Orders, and applicable Federal and state laws and regulations. Major requirements and goals are summarized in Table O.2–1.

**TABLE O.2–1.— Summary of Major Requirements and Goals Associated With Pollution Prevention, Water Conservation, and Energy Efficiency**

| Requirements and Goals  | Description   |
|---|---|
| <i>Pollution Prevention Act of 1990</i><br>(42 U.S.C. §13101 et seq.)                                   | This Act sets the national policy for waste management and pollution control that focuses first on source reduction, followed sequentially by environmentally safe recycling, treatment, and disposal. In response, DOE committed to voluntary participation in EPA's 33/50 Pollution Prevention Program, as set forth in Section 313 of SARA.  |
| RCRA Section 6002<br>(42 U.S.C. § 6962)   | This section of the Act directs Federal agencies to establish Affirmative Procurement Programs for acquiring recycled content products designated by EPA. RCRA Section 6002(c)(1) requires agencies to procure designated items composed of the highest percentage of recovered materials practicable. Procuring agencies may decide not to procure such items if they are not reasonably available in a reasonable period of time; fail to meet reasonable performance standards; or are only available at an unreasonable price.  |
| Comprehensive Guideline for Procurement of Products Containing Recovered Materials<br>(40 CFR Part 247) | This EPA guideline designates recycled content products pursuant to RCRA Section 6002.  |
| Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition<br>(EO 13101)      | This EO confirmed the requirement for Federal agencies to have affirmative procurement programs for EPA-designated guideline items. The EO further required that Federal agencies require that 100 % of their purchases of products meet or exceed EPA guidelines unless written justification is provided. The EO addressed solid waste prevention and recycling by requiring Federal agencies to establish goals for prevention and recycling or diversion to be met by 2000, 2005, and 2010.   |
| Greening the Government Through Efficient Energy Management<br>(EO 13123)                               | This EO directs Federal agencies to develop and implement energy management programs in order to reduce cost and emissions that contribute to air pollution and global climate change. The EO established goals for greenhouse gases reduction, energy efficiency, renewable energy use, and water conservation. DOE directs implementation of the EO through DOE O 430.2A.   |
| Greening the Government Through Leadership in Environmental Management (EO 13148)                       | This EO directs all Federal agencies to develop and implement environmental management systems to support environmental compliance; right-to-know disclosures requirements; pollution prevention; reducing toxic chemical releases; reducing use of toxic chemicals, hazardous substances, and other pollutants; reducing ozone depleting substances; and promoting environmentally and economically beneficial landscaping.  |
| Greening the Government Through Federal Fleet and Transportation Efficiency<br>(EO 13149)               | This EO requires Federal agencies that operate 20 or more motor vehicles to reduce its entire vehicle fleet's annual petroleum consumption by at least 20 % by the end of FY2005, compared with FY1999 petroleum consumption levels. Agencies have numerous options for developing a strategy to meet the petroleum reduction levels. Measures include the use of alternative fuels in light, medium, and heavy-duty vehicles; the acquisition of vehicles with higher fuel economy, including hybrid vehicles; the substitution of cars for light trucks; an increase in vehicle load factors; a decrease in vehicle miles traveled; and a decrease in fleet size. |

**TABLE O.2–1.— Summary of Major Requirements and Goals Associated With Pollution Prevention, Water Conservation, and Energy Efficiency (continued)**

| Requirements and Goals  | Description  |
|---|--|
| Federal Workforce Transportation (EO 13150)   | This EO addresses Federal employees' contribution to traffic congestion and air pollution. Federal agencies were required to implement a transportation fringe benefit program that offers qualified Federal employees the option to exclude employee commuting costs incurred through the use of mass transportation and vanpools from taxable wages and compensation.  |
| <i>Hazardous Waste Reduction Act</i> (California Health and Safety Code §25244.12-24)   | This Act expands the State of California hazardous waste source reduction activities to accelerate reduction in hazardous waste generation.  |
| DOE Secretary Memorandum on Pollution Prevention and Energy Efficiency Leadership Goals for FY2000 and Beyond, November 12, 1999 (Richardson 1999b) | <p>The memorandum established the following 14 goals for DOE facilities:</p> <ol style="list-style-type: none"> <li>1. Reduce waste from routine operations by 2005, using a 1993 baseline, for these waste types: <ol style="list-style-type: none"> <li>a. Hazardous waste by 90%.</li> <li>b. TRU waste by 80 %.</li> <li>c. LLW by 80 %.</li> <li>d. MLLW by 80 %.</li> </ol> </li> <li>2. Reduce releases of toxic chemicals subject to toxic chemical release inventory reporting by 90 % by 2005, using a 1993 baseline.</li> <li>3. Increase the purchase of electricity from clean energy sources. <ol style="list-style-type: none"> <li>a. Increase purchase of electricity from renewable energy sources by including provisions for such purchase as a component of requests for bids in 100 % of all future DOE competitive solicitations for electricity.</li> <li>b. Increase the purchase of electricity from less greenhouse gas-intensive sources including, but not limited to, new advanced technology fossil energy systems, hydroelectric, and other highly efficient generating technologies.</li> </ol> </li> <li>4. Retrofit or replace 100 % of chillers of greater than 150 tons of cooling capacity and manufactured before 1984 that use Class I refrigerants by 2005.</li> <li>5. Eliminate use of Class I ozone-depleting substances by 2010, to the extent economically practicable, and to the extent that safe alternative chemicals are available for DOE Class I applications.</li> <li>6. Reduce greenhouse gas emissions attributed to facility energy use through life-cycle cost effective measures by 25 % by 2005 and 30 % by 2010, using 1990 as a baseline.</li> <li>7. Reduce entire fleet's annual petroleum consumption by at least 20 % by 2005 in comparison to 1999, including improving the fuel economy of new light-duty vehicle acquisitions and by other means.</li> <li>8. Acquire each year at least 75 % of light-duty vehicles as alternative-fuel vehicles, in accordance with the requirements of the <i>Energy Policy Act</i> of 1992.</li> <li>9. Increase usage rate of alternative fuel in departmental alternative fuel vehicles to 75 % by 2005 and 90 % by 2010 in areas where alternative fuel infrastructure is available.</li> </ol> |

**TABLE O.2–1.— Summary of Major Requirements and Goals Associated With Pollution Prevention, Water Conservation, and Energy Efficiency (continued)**

| Requirements and Goals                          | Description  |
|---|--|
| DOE O 430.2A, “In-House Energy Management”      | <p>This Order contains the following energy usage and ozone-depleting substance reduction goals applicable to DOE or the operating contractor:</p> <ul style="list-style-type: none"> <li>• Reduce energy consumption per gross square foot (or other unit as applicable) for laboratory and industrial facilities through life-cycle cost-effective measures by 20 % by 2005 and 25 % by 2010, using 1990 as a baseline.</li> <li>• Increase the purchase of electricity from nonhydroelectric renewable energy sources by including provisions for such purchases as a component in all future DOE competitive solicitations for electricity. DOE will purchase 3 % of its total electricity needs from nonhydroelectric renewable energy sources by 2005 and 7.5 % of its total from nonhydroelectric renewable energy sources by 2010. Nonhydroelectric renewable energy is energy generated from solar, geothermal, biomass, or wind technologies.</li> <li>• Increase the purchase of electricity from less greenhouse gas-intensive sources, including but not limited to, new advanced technology fossil energy systems and other highly efficient generating technologies.</li> <li>• Increase use of off-grid generation systems, including solar hot water and solar electricity supporting the Million Solar Roofs initiative, solar outdoor lighting, small wind turbines, fuel cells, and other technologies, when such systems are life-cycle cost effective and offer other benefits.</li> <li>• Retrofit or replace all chillers of greater than 150 tons of cooling capacity and manufactured before 1984 that use Class I refrigerant by 2005.</li> <li>• Reduce greenhouse gas emissions attributed to facility energy use through life-cycle cost-effective measures by 30 % by 2010, using 1990 as a baseline. Greenhouse gas emissions are carbon dioxide emissions calculated by DOE’s Federal Energy Management Program from energy consumption reported by the contractor.</li> <li>• Apply energy efficiency criteria and sustainable design principles to new building designs and submit Energy Efficiency/Sustainable Design Reports to DOE’s Federal Energy Management Program on individual projects after completion of Title II design.</li> </ul> |
| DOE O 450.1, “Environmental Protection Program” | <p>This Order requires DOE sites to implement Environmental Management Systems, a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals. These systems must be part of the Integrated Safety Management Systems established pursuant to DOE P 450.4, Safety Management System Policy.</p>  |

EO = Executive Order; EPA = U.S. Environmental Protection Agency; RCRA = *Resource Conservation and Recovery Act*;  
SARA = *Superfund Amendments and Reauthorization Act*; TRU = transuranic; LLW = low-level waste; MLLW = mixed low-level waste;  
FY = fiscal year.

## **O.3 POLLUTION PREVENTION PROGRAMS**

### **O.3.1 History**

Since the early 1990s, LLNL has had a formal pollution prevention program. However, activities that had beneficial pollution prevention implications for LLNL began before the 1990s. Process improvements implemented in 1988 at the energetic materials and components testing facilities at Site 300 led to reductions in low-level and mixed radioactive waste (LLNL 1997a). In the early 1990s, DOE initiated a return on investment program to fund pollution prevention projects that pay for themselves within 3 years by reducing hazardous material usage and waste generation. LLNL has implemented more than 30 such projects, some of which are described in the following sections. Since 1991, LLNL has operated a site-wide paper recycling program (LLNL 2002ag). LLNL met the DOE recycling goal for sanitary solid waste of 45 percent long before the target date of 2005, necessitating the establishment of a higher goal, 66.7 percent, by 2005 (LLNL 2002cc).

More than 15 years ago, LLNL engineers conducted comprehensive energy audits with the purpose of identifying conservation opportunities. Implementation of energy conservation projects led to a reduction of energy consumption of 23 percent from 1990 levels (LLNL2002bi). Water usage has also been scrutinized and conservation efforts implemented, including revising irrigation practices to optimize and reduce water consumption. LLNL also replaced toilets with ultra low-flow models and retrofitted urinals to reduce water usage. Recently, a pilot program was implemented to evaluate waterless urinals.

LLNL has also established an affirmative procurement program to use its buying power in order to promote recycled-content products. In 2000, LLNL spent \$1.1 million on recycled-content products targeted by the U.S. Environmental Protection Agency (EPA) (LLNL 2001q).

### **O.3.2 Program Organizations**

The pollution prevention program strives to use a cross-disciplinary and inter-organizational approach to identify and address pollution prevention issues. Recent pollution prevention project teams included individuals from LLNL's Environmental Protection Department, the Chemistry and Materials Science Directorate, the Plant Engineering Department, Public Affairs Office, and DOE. These teams worked well enough together to win two "Champions of Green Government" awards from EPA (LLNL 2003bv). LLNL organizations leading the pollution prevention effort are the Pollution Prevention Team and the Energy Management Program. The Procurement and Material Department, Fleet Management, and Plant Engineering's Facility and Maintenance Management Division are other LLNL organizations that are responsible for certain aspects of pollution prevention.

The LLNL Pollution Prevention Team is within the Environmental Protection Department. The team works in conjunction with the directorates to devise and implement measures to eliminate or reduce wastes and pollutants. The team conducts pollution prevention opportunity assessments to help waste generators evaluate processes that generate pollution and identify prevention opportunities (e.g., using less hazardous raw materials, implementing closed-loop systems to eliminate discharges, and adding controls for greater process efficiency). The Pollution

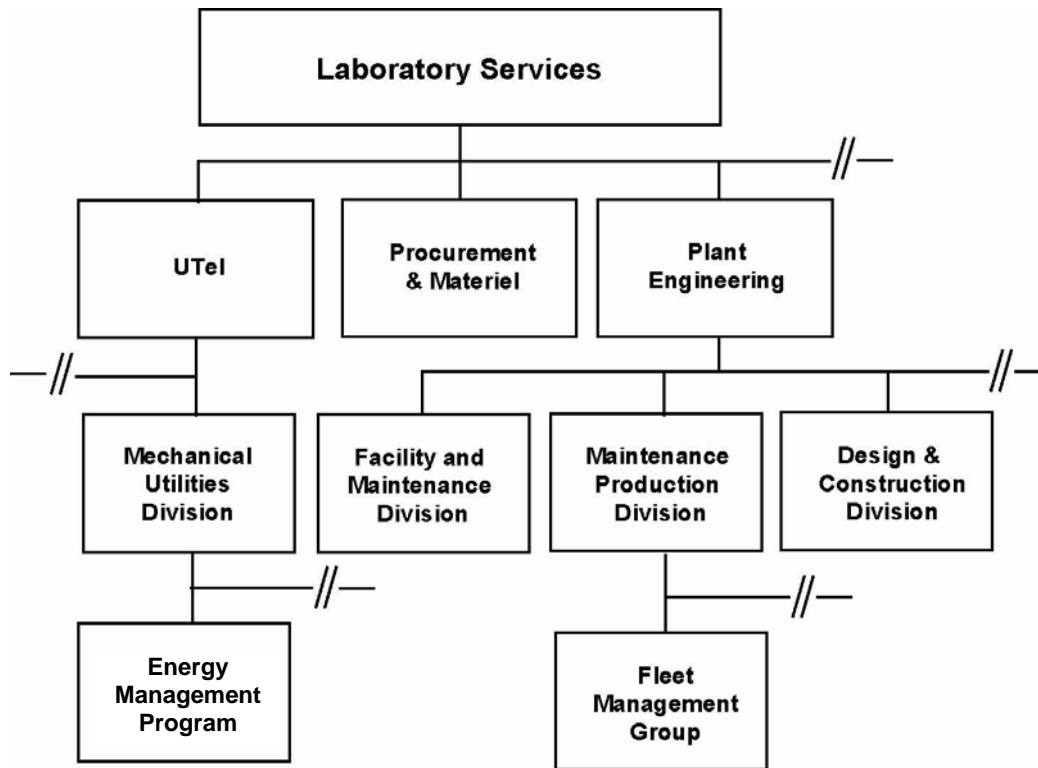
Prevention Team also assists the Energy Management Program in their integration of sustainable design into project planning, design, construction, and building life cycle management including equipment specifications and material design. The LLNL Environmental Protection Department also operates the Chemical Exchange Warehouse to promote chemical exchange rather than disposal (LLNL/EPD 2003).

The Pollution Prevention Team works with procurement and contracting officials, including Central Supply, the Print Plant, and the Procurement and Material Department, to implement the Affirmative Procurement Program. The Affirmative Procurement Program purchase recycled-content products. Purchasing recycled-content products is considered part of pollution prevention for its role in ensuring that a market for products manufactured from waste items is collected for recycling.

The Environmental Protection Department provides pollution prevention training and awareness and award programs for LLNL, including a site-wide Earth Expo coinciding with Earth Day that focuses on pollution prevention and natural resource conservation. Pollution prevention principles are promoted through new employee training and orientation, posters, articles in LLNL publications, administrative briefings, and memorandums. Pollution prevention requirements and responsibilities are documented for technical employees in Document 30.1, “Waste Minimization and Pollution Prevention,” of the Environment, Safety, and Health (ES&H) Manual (LLNL 2002cc).

Other aspects of pollution prevention include reducing energy consumption by LLNL facilities; water conservation; and off-grid energy generation systems. Incorporation of sustainable design practices in new facilities is promoted by Energy Management Program within the Laboratory Services Directorate (Figure O.3.2–1). It is Plant Engineering’s Design and Construction and Project Management Divisions that are responsible for project planning, design, and construction. The Energy Management Program also reports electricity, natural gas, and fuel oil consumption to DOE’s Federal Energy Management Program for the purposes of calculating greenhouse gas emissions.

Even though the Energy Management Program and the Pollution Prevention Team are not linked organizationally, the two teams often interact informally to promote pollution prevention. The Pollution Prevention Team also assists the Energy Management Program in promoting the integration of sustainable design into project planning, construction, de-construction, equipment specifications, and material selection.



**FIGURE O.3.2–1.—Laboratory Services Organization Showing Pollution Prevention Organizations**

Fleet Management, a part of the Plant Engineering Department’s Maintenance Production Division leads LLNL efforts to reduce petroleum consumption, thus conserving fossil fuels and reducing air pollution from the burning of fossil fuels. Fleet Management oversees LLNL’s fleet of cars and trucks, heavy equipment, and the bicycle program. Fleet Management also promotes car and vanpools through the Transportation Systems Management Program.

Plant Engineering’s Facility and Maintenance Management Division is responsible for retrofitting and replacing equipment that relies on ozone-depleting substances such as Freon. The Division is working toward phasing out ozone-depleting substances (ODSs) on a schedule based on DOE pollution prevention goals.

### **O.3.3 Sustainable Design**

Executive Order (EO) 13123, “Greening the Government through Efficient Energy Management,” and DOE O 430.2A, “In-House Energy Management,” require DOE to improve energy efficiency, conserve water, use renewable energy, and practice sustainable design.

Pollution prevention, energy efficiency, and water conservation are key elements in sustainable design. The sustainable design approach recognizes the fact that every design choice may have an impact on the natural and cultural resources of the local, regional, and global environments. This new design method incorporates life-cycle costs and associated impacts of a building’s construction; use, including installation and operation of equipment and human occupancy, and deconstruction into the earliest stages of design; thus front loading the design process with

criteria that would traditionally be considered after much of the design has been set. Breakthroughs in building science, technology and operations available to designers, builders, and owners are promoting sustainable design principles. The pollution prevention benefits of sustainable design include reduced indoor and outdoor air pollution, water discharges, and waste generation and conservation of natural resources through more efficient use of energy and materials.

LLNL has begun integrating this design approach into its design, contracting, and procurement elements. Traditionally, designing a building for LLNL took a linear approach. LLNL designers would plan the structure and then the building systems such as the electrical and heating, ventilation, and air conditioning would be added one at a time. Finally, the group that would occupy the building, and other support organizations such as the Environmental Protection Department, would review the completed drawings and plans. With this linear approach, pollution prevention and energy efficiency opportunities are more difficult to incorporate into the design.

LLNL has applied sustainable design principles to the International Security Research Facility, Building 140, and several other new facilities. Pollution prevention and energy efficiency were considered during the conceptual design phase, the earliest design phase. This approach applied during the early design phase leads to a more resource-efficient design.

Also, sustainable design principles were applied to the National Ignition Facility (NIF) project to identify opportunities for pollution prevention and energy efficiency. Recommendations were made for more energy efficient building insulation, chillers, cooling towers, and heating and cooling systems. The project also incorporates existing buildings, facilities, and resources saving materials and expenses. The project has developed pollution prevention plans for the construction, operation, and decommissioning phases.

To further integrate the sustainable design approach, LLNL and DOE began training managers and engineers using LEED™, the “Leadership in Energy & Environmental Design” principles developed by the U.S. Green Building Council. LLNL may require new construction and major renovation projects to be LEED™ Certified or rated.

The training has lead to LLNL incorporating selected sustainable design requirements into contract specifications. Several office buildings are planned for construction over the next few years. The contract specification for one of the first office buildings requires the designer to apply the following sustainable design principles (LLNL 2003bs):

- **Optimize Potential of Selected Site.** Site planning activities shall include evaluation of solar and wind orientation, local microclimate, drainage patterns, existing utilities, and site features to develop an optimal building site design and low-maintenance landscaping.
- **Minimize Energy Consumption.** Consider building orientation and massing, natural ventilation, daylighting, and other passive energy strategies that may lower a facility’s energy demand and utilization. Meet or exceed Federal and/or State of California energy performance standards for energy efficiency and additional details and considerations required by DOE O 430.2A.

- **Protect and Conserve Water.** Water conservation is enhanced by low-flow plumbing fixtures, appropriate landscaping, and the reuse of site runoff when feasible.
- **Use Environmentally Preferable Products.** Environmentally preferable building materials minimize life-cycle environmental impacts and minimize impact on occupant health. To the extent feasible, consider materials containing recycled content and salvage/recycle waste during construction.
- **Enhance Indoor Environmental Quality.** Appropriate ventilation/moisture control and the avoidance of materials and products with high volatile organic compound emissions will enhance occupant health and comfort.

### **O.3.4 Construction Practices**

To address pollution prevention during construction, LLNL includes standard measures for controlling pollution as part of every construction subcontract. Construction is defined to include building, renovating, modifying, painting, decorating, repairing, or demolishing of facilities and structures. For example, general construction practices at LLNL include contract specifications that require that fugitive emissions be reduced by water spraying of roads and the wheels and lower portions of construction vehicles (LLNL 2001r). To maximize recycling of building materials and minimize cost, demolition contractors with salvage operations are used whenever possible. The value of the recovered building material is sometimes partial compensation for the job.

To aid in the identification of mitigation measures, LLNL requires that subcontractors complete a project-specific task identification process list for all construction projects. This list, a questionnaire listing typical concerns and hazards, helps subcontractors identify potential topics to be addressed in project-specific compliance plans. This list (LLNL 2001r) contains specific line items that assist in the identification of requirements related to air resource protection during facility construction.

- Will construction equipment and vehicles be inspected daily for leaks of fuel, engine coolant, and hydraulic fluid?
- Will work involve chemicals, solvents, painting, welding, torch cutting, brazing, or grit blasting?
  - Are all paints in compliance with Bay Area Air Quality Management District limits on volatile organic compound content?
  - Will adequate measure be taken to prevent discharge of hazardous and regulated materials to the environment?
- Will the project involve concrete demolition or disturbance?
  - Has a 10-day notification to the Air District been submitted for any demolition?

- Will work involve jack hammering, roto-hammering, or other operations that may generate silica dust?
  - Describe how dust will be controlled and/or workers protected from silica hazards.
- Is there a possibility that asbestos containing materials will be encountered?
  - Has a 10-day notification to the Air District been submitted for renovations involving asbestos containing material greater than or equal to 100 linear feet, 100 square feet, or 35 cubic feet prior to renovation?
- Will adequate measures be taken to prevent discharge of hazardous and regulated materials to the environment?

In addition, the Environmental Protection Department provides guidance on construction projects, reviews the task identification process prior to construction, and routinely inspects construction sites to ensure adherence to project-specific requirements.

## **O.4 ACTIVITIES AND ACCOMPLISHMENTS**

This section includes descriptions of the various pollution prevention activities and projects recently completed and ongoing.

### **O.4.1 Air Quality**

LLNL controls its air emissions in compliance with stringent Federal, state, and local requirements. To maintain emissions below air quality standards, LLNL uses control measures, monitoring, new source pre-planning, and sustainable design planning for new facilities and buildings. In addition, LLNL has implemented pollution prevention activities as described below. These prudent measures have allowed LLNL to maintain its mid-size facility ranking (ranked on amount of total emissions), as confirmed by the site's continued eligibility to receive offset air release credits from the local air quality planning district.

Air quality issues targeted by the LLNL pollution prevention programs are discussed below. See Chapter 4 in Volume I for more information on air quality at LLNL and more complete lists of types and levels of air emissions.

#### **O.4.1.1 *Reduction of Stratospheric Ozone-Depleting Substances***

LLNL has actively pursued programs to reduce the use of stratospheric ozone-depleting substances, which include methylene chloride, 1,1,1-trichloroethane, the family of chemicals referred to as Freons, and halons. By 1997, ozone-depleting halogenated solvents had been replaced with nonhalogenated alternatives (e.g., acetone, ethyl acetate) in slurry coating plastic-bonded explosives (LLNL 1997a). The replacement of Freons has been a priority, and dramatic reductions in Freon use have been documented. Freon-113 from cleaning operations was reduced approximately 32 percent between 1994 and 1995. The largest user of Freon-113, the Atomic Vapor Laser Isotope Separation Program, ceased operations in 1999. Upon decommissioning of

this project's facility, 10,000 gallons of Freon-113 was removed from LLNL (LLNL 2003bl). DOE targeted the reduction of chemicals subject to Toxic Chemical Release Inventory (TRI) reporting in Goal 2 of its pollution prevention goals (Richardson 1999b). Due to these reduction efforts, Freon-113 is no longer reported by LLNL (DOE 2003m).

DOE targeted Class I ODSs used in cooling systems for phaseout in pollution prevention Goals 9 and 10 (Richardson 1999b). Class I ODSs have the highest ozone-depleting potential and include chlorofluorocarbon, halons, carbon tetrachloride, methyl chloroform, hydrobromofluorocarbon, and methyl bromide. LLNL has replaced or retrofitted all but seven of its chillers with greater than 150 tons of cooling capacity that use Class I refrigerants. The remaining seven chillers are scheduled for replacement by fiscal year (FY) 2007 (LLNL 2001q). Other LLNL chillers that contain Class I ODSs will also be replaced. The schedule for these replacements is FY2004 and FY2010 through FY2015. Some packaged air conditioning units and condensers also contain Class I refrigerants. LLNL has retrofitted or replaced all but 10 of these units and condensers (LLNL 2001q). LLNL plans to replace the eight units located at the Livermore Site by 2005. The two remaining units at Site 300 are being evaluated for replacement or removal from service (LLNL 2003bu).

In addition to chillers, some LLNL fire suppression systems contain halon, a Class I ODS. DOE's Goal 10 (Richardson 1999b) calls for the elimination of all Class I ODSs at DOE facilities. LLNL began removing fire suppression systems containing halon from service prior to Goal 10 being established. By 2001, only 15 systems remained at LLNL and all but one of these are scheduled to be replaced or upgraded by 2010 to eliminate the use of halon (LLNL 2001q). The remaining system using halon is being evaluated for replacement, upgrade, or removal from service (King 2003a).

#### **O.4.1.2      *Reduction of Greenhouse Gases***

DOE listed the reduction of greenhouse gas production attributed to facility energy use as Goal 11 of its pollution prevention and energy efficiency goals (Richardson 1999b). LLNL reduces its contribution to greenhouse gases in the atmosphere through its energy efficiency efforts. LLNL has reduced its consumption of electricity, fuel oil, and natural gas in the past several years (see Chapter 4 in Volume I for consumption levels and reduction percentages). When compared to the baseline year, FY1990, LLNL had achieved a 23-percent reduction in energy use per square foot of floorspace (LLNL 2002bi) and a 25-percent reduction in greenhouse gas emissions (FEMP 2002a). The following text box describes the greenhouse effect and greenhouse gases.

### The Greenhouse Effect



Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the earth's surface and the lower atmosphere.

### What Are Greenhouse Gases?

Energy from the sun drives the Earth's weather and climate, and heats the Earth's surface; in turn, the earth radiates energy back into space. Atmospheric greenhouse gases (water vapor, carbon dioxide, and other gases) trap some of the outgoing energy, retaining heat similar to the glass panels of a greenhouse. Without this natural "greenhouse effect," temperatures would be much lower than they are now, and life as known today would not be possible. Instead, thanks to greenhouse gases, the Earth's average temperature is a more hospitable 60°F. However, problems may arise when the atmospheric concentration of greenhouse gases increases.

Since the beginning of the industrial revolution, atmospheric concentrations of carbon dioxide have increased nearly 30 percent; methane concentrations have more than doubled; and nitrous oxide concentrations have risen by about 15 percent. These increases have enhanced the heat-trapping capability of the Earth's atmosphere. Some greenhouse gases occur naturally in the atmosphere, while others result from human activities. Naturally occurring greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Certain human activities, however, add to the levels of most of these naturally occurring gases.

It's well accepted by scientists that greenhouse gases trap heat in the Earth's atmosphere and tend to warm the planet. By increasing the levels of greenhouse gases in the atmosphere, human activities are strengthening the Earth's natural greenhouse effect. The key greenhouse gases emitted by human activities remain in the atmosphere for periods ranging from decades to centuries.

A warming trend of about 1°F has been recorded since the late 19th century.

*Carbon dioxide* is released to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), and wood and wood products are burned.

*Methane* is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from the decomposition of organic wastes in municipal solid waste landfills, and the raising of livestock.

*Nitrous oxide* is emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels.

Very powerful greenhouse gases that are not naturally occurring include *hydrofluorocarbons* (HFCs), *perfluorocarbons* (PFCs), and *sulfur hexafluoride* (SF<sub>6</sub>), which are generated in a variety of industrial processes.

Source: EPA 2003e.

#### **O.4.1.3      *Vehicular Activity and Transportation Demand Management***

In efforts to improve air quality, decrease traffic congestion, and conserve fossil fuels, LLNL has been active in promoting alternative, environmentally responsible options for employee commuting. LLNL has a transportation systems management program that provides the following (LLNL 2001s):

- A pre-tax benefit program for transit and vanpool commuters, which enables employees to set aside a fixed amount of their pre-tax salary each month to reduce transportation costs
- Participation in the local air quality organization's "Spare the Air" Program
- Active participation in meetings with local transportation planners, other large employers, local school districts, and community outreach programs to mitigate transportation-related air pollution and congestion-management issues
- Participation in DOE's Clean Cities Coalition to increase availability and use of alternative-fueled vehicles for LLNL employees

Specifically, the transportation systems management program helps employees find ways to join a carpool, vanpool, take public transportation, or ride a bike to work. LLNL provides preferential parking and a guaranteed ride home for carpool and vanpool riders who miss their rides. In addition, vanpools or "vanpool participants" with seven or more passengers can buy fuel at LLNL, taking advantage of lower fuel costs afforded to LLNL due to its bulk buying power. Shuttle service is provided between LLNL and train stations, bus stops, and the Sandia National Laboratories/California. Free bus passes are also available under certain circumstances (LLNL 2003bk). The impact to air quality has not been quantified, but according to the EPA, the average car driving 12,500 miles in one year emits 80 pounds of hydrocarbons, 600 pounds of carbon monoxide, 40 pounds of nitrogen oxides, and 10,000 pounds of carbon dioxide (LLNL 2003bm).

#### **O.4.1.4      *Recent Air Emissions Reduction Projects***

##### **Precursor Organic Solvent Use and Recycling**

In order to reduce environmental risk associated with the use of many problematic cleaning solvents, LLNL conducted an in-depth analysis of 75 chemical alternatives and evaluated each according to cleaning performance, health effects, and environmental impacts. As a result, 25 laboratory shops stopped using the more problematic chemicals and switched to safer alternatives, many of them nonhazardous products that generate no toxic air emissions or liquid wastes (LLNL 1997a).

Within the Energetic Materials Program, hexane has been replaced with ice water in chemical processes for producing mock high explosives. In-process distillation and condensation of solvents driven off during the formulation of plastic explosives has also reduced air emissions, together with recycling and reusing solvents and explosives recovered in experiments, and screening all chemicals introduced into experiments to encourage the use of more

environmentally compatible input chemicals. Within the Aerogel Manufacturing Process, a project was undertaken to evaluate and successfully reuse spent methanol solvent (LLNL 1997a).

At Site 300 maintenance and automotive fleet operations, oil-based paints have been replaced with environmentally compatible water-based substitutes to reduce volatile emissions, and paint is applied with high-volume, low-pressure applicators to reduce the amount of paint required for each job. In addition, lacquer thinner has been substituted for methyl ethyl ketone and paint thinner as a cleaner. Spent lacquer thinner is reclaimed with an onsite solvent recovery unit, and reused in paint shop operations, thus reducing hazardous waste.

### **Dry Powder Coating Paint Process**

The liquid spraying operation for solvent and water-based paints, polyurethanes, and epoxies at a paint spray booth was replaced with a dry powder coating process. The dry powder process eliminated the emission of all volatile organic compounds (VOCs) from the paint booth since powdercoating materials do not contain VOCs. The VOC reduction has been estimated at 450 kilograms per year (LLNL 2003bn). This process change also eliminated the hazardous waste associated with partially used paint containers, use of solvents, and solvent rags from cleaning the spray equipment. The hazardous waste reduction is estimated at 500 kilograms per year (LLNL 2003bn).

### **Contained Firing Facility**

The Contained Firing Facility replaced an outdoor firing table. Moving the facility indoors resulted in reduced air emissions (LLNL 2003bm).

## **O.4.2 Water**

LLNL prevents pollution of surface water and groundwater by following operating procedures, permit requirements, and best management practices, and by maintaining equipment. LLNL also has a Spill Prevention Control and Countermeasures Plan to address potential contamination sources. Surface water and groundwater are also protected by reducing pollutants in stormwater runoff. The LLNL stormwater pollution prevention plans have been prepared to identify pollutant sources that affect the quality of industrial stormwater discharges and to describe implementation practices to reduce pollutants in the discharges.

LLNL is also committed to using water in a conservative manner. Beginning in 1988, LLNL began curtailing water use by implementing water conservation measures, including reducing landscape watering and reducing blowdown in cooling towers to minimal operable levels. LLNL has also replaced and upgraded water distribution lines at various locations, reducing water use at the site. Many areas of LLNL are landscaped with plants that require only small amounts of water (xeric plants) to reduce the amount of water required for irrigation. In addition, LLNL continues to monitor water use to discourage waste or unnecessary use. LLNL has also undertaken site-specific projects to reduce water consumption. As a result of conservation efforts, LLNL currently uses about 14 percent less water than in FY1993 per building square foot (LLNL 2002bi). Chapter 4 has more information on water quality at LLNL, a discussion on sewer discharges, and a discussion of industrial wastewater. Pollution prevention projects that reduce wastewater discharges and conserve water are discussed below.

#### **O.4.2.1      *Building 322 Evaporator***

The Building 322 cold evaporator recycles rinsewater from plating operations. The evaporator allows the reuse of approximately 99 percent of the rinsewater. Additionally, the plating shop converted continuous flow rinses into spray stations and uses ultrasonic cleaning techniques. All of these activities have reduced the quantity of wastewater and conserved water (LLNL 2003bq).

#### **O.4.2.2      *Drain-Down Water Recovery***

LLNL developed and implemented a new pollution prevention and cost savings approach to traditional chilled and hot water circulating system maintenance drain and refill practice. A mobile trailer with 1,000-gallon storage capacity and pumping capability was built using mainly surplus equipment. The mobile trailer is towed to the building to receive repairs or preventative maintenance. The chemically treated water is drained out of the building's system and stored in the mobile trailer. After maintenance is completed the water is pumped back into the system. This pollution prevention activity has created several benefits including reduced water consumption, recovery and reuse of water treatment chemicals, elimination of chemically treated circulating water discharges, elimination of monitoring of these discharges to the public sewer, and reduced labor costs and building system down time. This activity conserves approximately 72,600 gallons of water, reduces wastewater discharged to the sewer by the same amount, and reduces the use of corrosion and scale inhibiting chemicals by 590 gallons, annually (LLNL 2003bn).

#### **O.4.2.3      *Vehicle Wash Reclamation System***

A water reclamation system at the LLNL Fleet Maintenance Vehicle Wash Facility recycles approximately 70 percent of the water. This system conserves approximately 440,000 gallons of water, reduces wastewater discharged to the sewer by the same amount, and reduces the use of soap by 77 gallons, annually (LLNL 2003bn).

#### **O.4.2.4      *Retrofit of Ultra Low-Flow Toilets and Sensor Type Urinal Flush Valves***

During FY2000 and FY2001, the Energy Management Program, in partnership with the Facility Maintenance Division, retrofitted 154 ultra low-flow toilets and 77 sensor-type urinal flush valves in existing buildings. Estimated annual water and cost savings are 6.8 million gallons and \$40,000, respectively. Cost savings account for reduced water purchases, electricity demand for water pumping, and sewer discharge fees (LLNL 2003bp).

#### **O.4.2.5      *Waterless Urinal Pilot Project***

During FY2003, 10 waterless urinals were installed in selected office buildings as a pilot project to assess employee acceptance. The pilot project is estimated to save about 200,000 gallons of water annually. Even before the pilot project was completed, plans were developed to install waterless urinals in two additional office buildings (LLNL 2003bp).

### O.4.3 Energy Management

The Energy Management Program is responsible for promoting reduced energy consumption and reducing the impact of energy costs on LLNL operations. This responsibility is primarily accomplished through energy conservation awareness and retrofitting building systems to improve energy efficiency. To achieve this goal, the Energy Management Program performs studies and conducts surveys to identify opportunities for applying energy management principles, including:

- Energy conservation
- Electrical load management—Revising operations so that high energy demand operations are done during offpeak hours. Offpeak energy is usually less expensive and results in a cost savings. This does not reduce energy use, but could eliminate/postpone the need for additional power generation facilities in the region, thus reducing potential for environmental impacts to air and water.
- Use of alternative “green energy” sources (does not reduce the amount of energy used, but utilizes environmentally friendly generation resources)

The Energy Management Program draws on all three of these principles as discussed in the following subsections.

#### O.4.3.1 Energy Conservation

Through energy conservation efforts, LLNL has achieved a 23-percent energy use reduction per square foot of floorspace based on the baseline year of FY1990 (LLNL 2002bi). DOE set a goal for reducing energy consumption through life-cycle, cost-effective measures by 20 percent by 2005 and 25 percent by 2010 (Richardson 1999b). LLNL achieved the 2005 goal 3 years ahead of schedule. Table O.4.3–1 presents energy consumption for FY2000 through FY2002. The energy consumption amounts do not include the energy used for construction of facilities or buildings.

**TABLE O.4.3–1.—Energy Consumption at the Lawrence Livermore National Laboratory**

| Energy Type                          | Baseline Year |         |         |         |
|--------------------------------------|---------------|---------|---------|---------|
|                                      | 1990          | FY2000  | FY2001  | FY2002  |
| Electricity (million kilowatt hours) | 350           | 270     | 290     | 300     |
| Natural gas (million cubic feet)     | 430,000       | 450,000 | 440,000 | 460,000 |
| Fuel oil (thousand gallons)          | 63            | 9.9     | 11      | 12      |

Source: FEMP 2002a.

Seven energy efficiency projects were completed during FY2002. These projects involved retrofits for energy efficiency in building heating, ventilation, and air conditioning systems, vending machine systems, central compressed air plant and distribution system piping, and boiler/chilled water system repair procedures. Expected energy savings are about 2.13 million kilowatt hours per year of electric power and 97,200 therms per year of natural gas (LLNL 2002bi).

The Energy Management Program worked with plant engineering organizations to change procurement practices for greater energy efficiency in building boiler systems. Building boiler equipment specifications now require modulating-condensing boiler systems for new and replacement boilers whenever life-cycle cost effective. The boilers are up to 95 percent energy efficient.

The Energy Management Program is working with other LLNL organizations in integrating sustainable design principles for new facilities leading to energy efficient facilities equipped with energy efficient lighting, electronics, machinery, and building automation systems. The Terascale Simulation Facility, the Building 140 project, and new office buildings were and are being designed using sustainable design principles.

#### **O.4.3.2      *Load Management***

Given California's electrical energy situation, LLNL initiated a voluntary plan that included load management and conservation measures. The implementation of this plan reduced annual consumption by 8 percent and earned LLNL a DOE energy management award (FEMP 2002b). The plan was developed by a team from the Site Utilities Division and then marketed by its management to all building facility managers and building coordinators. Changes included:

- Large water pumping operations changed their operating hours to offpeak periods
- Several LLNL experimenters changed to off-hour operations
- Numerous building locations use only the minimal lighting at all times
- Thermostat settings were lowered during the heating season and raised during the cooling season
- Building controls were set to schedule operations

#### **O.4.3.3      *Renewable Energy Use***

DOE also set a goal to increase the purchase of electricity from clean energy sources (Richardson 1999b). DOE plans to seek renewable energy sources when contracts for power use in 2004 and beyond are negotiated.

LLNL has also made efforts to use renewable energy sources whenever possible. Selected groundwater treatment systems at the Livermore Site and Site 300 use solar power. Building 543 has a solar-heated domestic water system; two other renewable energy projects at LLNL use photovoltaic technology. The Energy Management Program is investigating additional renewable energy projects.

LLNL's Pollution Prevention Team and Energy Management Program worked together to implement a photovoltaic technology exhibit at the LLNL Discovery Center. A range of configurations and panel types were installed, allowing LLNL guests to view several outdoor settings and to better understand the value of photovoltaic power systems. An interactive computer display shows instantaneous and historical performance of each system. The

generating capacity is currently around 3.5 kilowatts, but has the ability to expand up to 7.5 kilowatts (LLNL 2003bn).

Twenty-one photovoltaic powered lights illuminate a parking lot and walkways at the Livermore Site, improving safety at night. The effort was funded primarily by rebates received from electricity suppliers for energy efficiency projects from the previous years (LLNL 2002bi).

#### **O.4.4           Transportation**

To conserve fossil fuels and reduce the generation of greenhouse gases as related to transportation, LLNL Fleet Management reduces petroleum consumption, uses alternative fuels, and encourages carpooling and vanpooling, and use of mass-transit by LLNL employees.

##### **O.4.4.1       *Lawrence Livermore National Laboratory Fleet***

LLNL maintains a fleet of vehicles for transportation both on site and offsite. DOE targeted vehicle fleets in its Pollution Prevention and Energy Efficiency Leadership Goals (Richardson 1999b). The Pollution Prevention Team and LLNL Fleet Management have been working together on pollution prevention and fossil fuel reduction efforts.

LLNL is pursuing a broad strategy to reduce fossil fuel consumption including use of alternatively-fueled vehicles, the acquisition of and increased reliance on vehicles with higher fuel economy, use of small electric vehicles and carts and bicycles for onsite transportation, and incorporation of electric cars into the fleet for onsite and offsite transportation. With reduced gasoline consumption comes pollution prevention benefits including smaller amounts of air pollutants and greenhouse gases being released to the atmosphere. LLNL currently has vehicles that can run on compressed natural gas or gasoline. These vehicles are fueled onsite (LLNL 2001q).

The LLNL Bike Program supports transportation by bicycle on the 1 square mile Livermore Site. LLNL owns and maintains about 800 bicycles for use by LLNL employees. The program saves an estimated 34,000 gallons of gasoline and 10,000 gallons of diesel fuel annually (LLNL 2003bk).

The latest strategy to reduce gasoline consumption and air pollution is the incorporation of 20 electric cars into the LLNL fleet. This pilot project began in FY2003 to evaluate if these automobiles can effectively meet LLNL transportation needs while reducing fossil fuel consumption. The pilot project was successful and led to the purchase of additional electric cars. LLNL estimates that the original 20 cars could reduce gasoline usage onsite by more than 6,000 gallons per year. The California Air Resources Board estimates that zero emission vehicles such as these in use at LLNL are approximately 95 percent cleaner than the lowest emitting conventional vehicle (LLNL 2003bo).

Executive Order 13149 requires DOE with reducing petroleum consumption of its entire fleet (LLNL and all other DOE sites) at least 20 percent by the end of FY2005, compared with FY1999 petroleum consumption levels. DOE developed a strategy for achieving this goal (OTT 2001). Strategies for reducing petroleum consumption include use of biodiesel (see text box, “What is Biodiesel?”), which could decrease conventional diesel fuel use by 18 percent (OTT

2001). LLNL is investigating a pilot project to use biodiesel fuel in some LLNL vehicles. An additional strategy named in this Executive Order is the use of hybrid vehicles. Hybrid vehicles operate on electricity and gasoline. LLNL plans to evaluate the lease of hybrid vehicles.

#### **O.4.4.2      *Lawrence Livermore National Laboratory Commuters***

LLNL helps employees discover ways to join a carpool, vanpool, take public transportation, or ride a bike to work. LLNL provides preferential parking and a guaranteed ride home program for carpool and vanpool riders who miss their rides. In addition, vanpools or “vanpool participants” with seven or more passengers can buy fuel at LLNL, taking advantage of reduced fuel costs afforded to LLNL due to its bulk buying power. More than 400 carpools and 30 vanpools have been formed for commuting to LLNL (LLNL 2003bk). Shuttle service is provided between train stations, bus stops, and Sandia National Laboratories/California. Free bus passes are also available under certain circumstances. Annual savings to the employees is estimated at 540,000 gallons of gasoline with an additional 5,500 gallons of diesel fuel expended by bus and train services (LLNL 2003bk).

#### **What is Biodiesel?**

Biodiesel (fatty acid alkyl esters) is a cleaner-burning diesel replacement fuel made from natural, renewable sources such as new and used vegetable oils and animal fats. Just like petroleum diesel, biodiesel operates in compression-ignition engines. Blends of up to 20 percent biodiesel (mixed with petroleum diesel fuels) can be used in nearly all diesel equipment and are compatible with most storage and distribution equipment. These low level blends, 20 percent and less, don't require any engine modifications and can provide the same payload capacity and as diesel. Users should consult their engine warranty statement.

Higher blends, even pure biodiesel (100 percent biodiesel, or B100), can be used in many engines built since 1994 with little or no modification. Transportation and storage, however, require special management. Material compatibility and warrantee issues have not been resolved with higher blends.

Using biodiesel in a conventional diesel engine substantially reduces emissions of unburned hydrocarbons, carbon monoxide, sulfates, polycyclic aromatic hydrocarbons, nitrated polycyclic aromatic hydrocarbons, and particulate matter. These reductions increase as the amount of biodiesel blended into diesel fuel increases. The best emissions reductions are seen with B100.

The use of biodiesel decreases the solid carbon fraction of particulate matter since the oxygen in biodiesel enables more complete combustion to carbon dioxide and reduces the sulfate fraction (biodiesel contains less than 24 parts per million sulfur), while the soluble, or hydrocarbon, fraction stays the same or increases. Therefore, biodiesel works well with new technologies such as diesel oxidation catalysts, which reduce the soluble fraction of diesel particulate but not the solid carbon fraction.

Emissions of nitrogen oxides increase with the concentration of biodiesel in the fuel. Some biodiesel produces more nitrogen oxides than others, and some additives have shown promise in modifying the increases. More research and development is needed to resolve this issue.

Biodiesel has physical properties very similar to conventional diesel.

Source: DOE 2003n.

## O.4.5 Materials and Waste Management

### O.4.5.1 Affirmative Procurement of Materials

The Affirmative Procurement Program at LLNL is a cooperative effort between everyone with purchasing responsibilities. The categories of products included in the Affirmative Procurement Program are listed in Table O.4.5.1–1 along with the percentage of the total dollars of purchased products that had recycled-content. In FY2002, 59 percent of the funds LLNL spent on these products were for recycled-content products (DOE 2003d).

**TABLE O.4.5.1–1.—Affirmative Procurement FY2002 Purchases**

| Product Category                                      | Total Purchases        | Percentage of Dollars Spent on Recycled-Content Products |
|---|------------------------|--|
| Construction  | \$760,000              | 52%  |
| Landscaping   | \$0                    | NA   |
| Nonpaper office supplies                              | \$590,000              | 35%  |
| Paper and paper products                              | \$1,100,000            | 79%  |
| Parks and Recreation materials                        | \$0                    | NA   |
| Transportation related products (e.g., traffic cones) | \$3,000                | 100%   |
| Vehicular maintenance products                        | \$120,000 <sup>a</sup> | 16%  |
| Miscellaneous   | \$100,000              | 91%  |

Source: DOE 2003d.

<sup>a</sup> Includes cost of re-refined oil provided by LLNL 2003br.

NA = Not applicable.

A few highlights of the Affirmative Procurement Program that contributed to this achievement include (LLNL 2003bx):

- Virgin paper at Central Supply can only be purchased after a consultation with the Pollution Prevention Team that does not result in identifying an acceptable recycled-content product.
- Ninety-nine percent of the paper used by the LLNL Print Plant is recycled-content paper.
- EPA-designated construction products were incorporated into the master construction specifications that must be followed during all construction projects at LLNL.
- LLNL Fleet Management exclusively uses re-refined oil and recycles antifreeze in-house.
- LLNL does not have to purchase compost and mulch products (virgin or recycled-content) because LLNL produces its compost from landscaping trimmings and its mulch from chipping donated Christmas trees.

In addition, to promote the purchase of recycled-content products beyond the LLNL procurement organizations, the Pollution Prevention Team trains technical release representatives on affirmative procurement. Technical release representatives are individuals within the various LLNL directorates who can directly purchase products offsite (LLNL 2003bx).

### O.4.5.2 Waste Minimization

Since 1993, LLNL implemented many waste minimization practices, changed processes, added recycling systems, and made chemical substitutions to dramatically lower the amount of waste generated and increase the amount of material recycled. Table O.4.5.2–1 presents routine waste generation amounts and the reduction percentages achieved. The baseline year, 1993, was established in the pollution prevention leadership goals (Richardson 1999b). The low-level radioactive, hazardous, and mixed wastes reduction percentages are 57, 57, and 89 percent, respectively. Some of the more recent pollution prevention projects that have contributed to these reductions are described below. More information on waste generation is presented in Chapter 4 and Appendix B.

**TABLE O.4.5.2–1.—Routine Waste Generation Amounts and Reduction Percentages**

| Waste Category                          | FY1993<br>Baseline | FY2001 | FY2002 | Reduction<br>Achieved |
|---|--------------------|--------|--------|-----------------------|
| Low-level radioactive<br>(cubic meters) | 188                | 65     | 81     | 57%                   |
| Hazardous<br>(metric tons)              | 615                | 195    | 262    | 57%                   |
| Mixed<br>(cubic meters)                 | 98                 | 17     | 10     | 89%                   |

Source: DOE 2002s.

LLNL also focuses waste minimization and recycling efforts on sanitary solid waste and nonroutine, nonhazardous waste from construction and decommissioning projects. DOE's pollution prevention goals (Richardson 1999b) address the need to reduce and recycle these wastes. The amount of sanitary waste generated in FY2002 was 5,800 metric tons, which is only 1 percent less than that generated in 1993. However, 4,000 metric tons (69 percent) was diverted into recycling and reuse opportunities (LLNL 2003l). LLNL generated 22,000 metric tons of nonroutine, nonhazardous waste in FY2002 of which 15,000 metric tons were reused or recycled (LLNL 2003l). Most of the 15,000 tons were asphalt/concrete and clean or Class 2 contaminated soil. Asphalt/concrete is chipped and used as road base at a local landfill. The soil is beneficially used as daily cover at local landfills and no tipping fee is charged. Table O.4.5.2–2 lists the wastes and amounts that were diverted for recycling or reuse in FY2001 and FY2002.

The LLNL Space Action Team manages decommissioning projects. This team is an integrated, multidisciplinary, multiorganization, cross-trained team specifically designed to perform cradle-to-grave decommissioning projects. This team makes efforts to disposition chemicals and equipment from decommissioning projects. The Space Action Team was successful in recycling approximately 90 percent of materials including soil, asphalt, concrete, wood, steel, scrap metal, and electromechanical infrastructure and equipment during the demolition of 11 buildings and 11 trailers at LLNL (EPA 2003b). The Space Action Team also had similar waste reduction accomplishments on the decommissioning of the Atomic Vapor Laser Isotope Separation Facility. Waste reduction highlights include the following chemical waste diversions and distribution of equipment to new users (LLNL 2003bl). The Space Action Team also accumulates laboratory glassware during its decommissioning work for donation to area high schools (LLNL 2003bl).

**TABLE O.4.5.2—Waste Diverted for Recycling and Reuse in FY2001 and FY2002**

| <b>Material</b>                    | <b>FY2001 (metric tons)<sup>a</sup></b> | <b>FY2002 (metric tons)<sup>b</sup></b> |
|------------------------------------|---|---|
| Asphalt/concrete                   | 2,800                                   | 1,900                                   |
| Batteries                          | 19                                      | 22                                      |
| Beverages and food containers      | 20                                      | 8                                       |
| Cardboard                          | 130                                     | 147                                     |
| Compost                            | 470                                     | 700                                     |
| Cooking grease/oil                 | 4.4                                     | 2.8                                     |
| Soil                               | 4,300                                   | 12,000                                  |
| Magazines, newspapers, phone books | 28                                      | 30                                      |
| Metals                             | 1,300                                   | 1,400                                   |
| Miscellaneous                      | NA                                      | 1.6                                     |
| Nonroutine metals                  | NA                                      | 780                                     |
| Paper                              | 260                                     | 300                                     |
| Pipette boxes                      | NA                                      | 1.0                                     |
| Recycled by Waste Management       | Not reported                            | 230                                     |
| Surplus sales                      | Not reported                            | 700                                     |
| Tires and scrap                    | 24                                      | 27                                      |
| Toner cartridges                   | 1.7                                     | 1.5                                     |
| Wood                               | 440                                     | 550                                     |

<sup>a</sup> Source: LLNL 2002cc.<sup>b</sup> Source: LLNL 2003l.

- The sale of 10,000 gallons of Freon-113, after it had been declined for reuse by other areas of DOE and the Department of Defense. In addition to the waste minimization and financial benefits of the Freon sale, removal of the Freon from the LLNL site allowed the cancellation of the associated Bay Area Air Quality Management District air permits and helped LLNL achieve a negative declaration on the required TRI Report for Reporting Year 2000.
- The identification of a company to take approximately 7,000 gallons of 94 percent ethanol from the LLNL site for processing into fuel and industrial grade ethanol at essentially no cost to LLNL. (This path of disposition provided a preferable alternative to disposal of the ethanol as hazardous waste).
- The take-back of 575 pounds of calcium and magnesium by the manufacturer. (This option was highly favorable in comparison to the estimated cost for disposal of the metals.)
- The take-back of 8,595 pounds of graphite parts by a company in Long Beach, CA. Prior to reuse, the company was able to remove (grind off) sensitive USEC parts numbers.
- The sale, rather than disposal, of 100 kilograms of cerium and 540 kilograms of gadolinium.

## **O.4.6 Recent Pollution Prevention Projects**

### **O.4.6.1 *Site 300 Firing Tables***

When designing experiments, Defense and Nuclear Technologies employees consider pollution prevention opportunities. The organization began using reusable steel tables and other steel or aluminum equipment in its experiments instead of one-time use wooden equipment. The steel tables can be used up to 20 times. In addition, equipment is “right-sized” for each experiment, so a minimal amount of material must be discarded after the experiment is completed. These measures, along with previously implemented waste minimization techniques, have reduced the wastes from this program area by more than 95 percent (LLNL 2003bl).

### **O.4.6.2 *Tritium Recovery and Reuse***

LLNL’s Tritium Facility, in cooperation with the U.S. Army, is recovering tritium from field devices. The project involves disassembling the units and segregating the tritium-containing ampules from nonradioactive components. The tritium is released from the ampules, captured, and accumulated in shipping containers. The containers are sent to the DOE Savannah River Site facility for reuse of the tritium. During FY2001, this waste minimization project recovered an estimated 27,000 curies of tritium. In addition to providing tritium for reuse by the DOE complex, the U.S. Government benefits by realizing a waste avoidance of approximately 7 tons of radioactive waste (LLNL 2003bl).

### **O.4.6.3 *Passive Groundwater Treatment Systems***

LLNL has designed and put into use two passive groundwater treatment systems at Site 300: the Passive Aboveground Iron Filings Groundwater Treatment System and the solar-powered Containerized Wetland System. Use of these systems reduces the volume of waste requiring disposal. In addition, they do not use any energy (LLNL 2003bl).

### **O.4.6.4 *Easy Pump Specific Depth Sampling Device***

An LLNL employee invented the easy pump specific depth sampling device in the early 1990s. LLNL worked to obtain regulatory acceptance in order to substitute the use of this sampling method in well locations previously sampled using traditional protocols and equipment. The Easy Pump is a low-cost, highly effective and safe device that can be used to obtain a groundwater sample without generating any purge water. This waste minimization technology is being transferred to other DOE sites and the private sector.

Since 1997, the Easy Pump has been used increasingly at LLNL. As old, dedicated pump equipment fails or requires significant maintenance, the old equipment may be removed and the Easy Pump used instead. Approximately 50 percent of LLNL wells are sampled using the Easy Pump, greatly reducing the amount of waste generated; approximately 50,000 gallons of contaminated groundwater would not be purged. An average sampling event with the Easy Pump takes 5 minutes compared to an average 50 minutes for an event using standard methods (LLNL 2003bl).

#### **O.4.6.5      *Lawrence Livermore National Laboratory Fleet Maintenance Facility***

The Fleet Maintenance Facility has implemented a number of pollution prevention projects, such as the installation of a recycling machine for reclaiming antifreeze for their use. Recycling antifreeze reduced the waste antifreeze, a hazardous waste, by 98 percent. The facility converted its solvent parts cleaning and its aerosol brake cleaning operations to aqueous cleaning operations, further reducing its hazardous waste stream. Additionally, the vehicle wash water recycling system is utilized by the facility (King 2003b).

### **O.5            RESEARCH AND DEVELOPMENT OF POLLUTION PREVENTION TECHNOLOGIES**

LLNL often conducts research and development (R&D) into technologies that have implications for pollution prevention. The following discussions regard some of the more recent research efforts that hold promise for advancing pollution prevention and energy conservation for government, businesses, and individuals.

#### **O.5.1            Hydrogen Fuel Storage Tank for Automobiles**

LLNL has long been involved in R&D of alternative energy technologies for transportation, including hydrogen fuel. Hydrogen-fueled cars can eliminate automotive air pollution and reduce or eliminate greenhouse gas emissions from transportation if the hydrogen fuel is produced from nonfossil energy resources.

A team in LLNL's Energy Technology and Security Program designed and tested a safe and compact system for on-vehicle storage of hydrogen fuel. The tank can safely and simultaneously accommodate three forms of hydrogen fuel—conventional high-pressure hydrogen gas, cryogenic compressed gaseous hydrogen, and liquid hydrogen. It does so while minimizing the storage challenges and maximizing the potential energy efficiency of each (LLNL 2003bt).

Next, this research plans to address installing the insulated cryogenic pressure vessels on vehicles for field testing. A second-generation tank is being developed, which will hold 9 kilograms of liquid hydrogen, energy equivalent to 9 gallons of gasoline. The work involves collaboration with a manufacturer of pressure vessels and the mass transit agency serving the Palm Springs, California area (LLNL 2003bt).

#### **O.5.2            Reducing Aerodynamic Drag on Heavy Duty Trucks to Improve Fuel Efficiency**

For more than 5 years, LLNL has led a DOE project to examine possible ways to make heavy trucks more aerodynamic, reducing air resistance and thus increasing fuel efficiency. LLNL engineers estimate that truck drag could be reduced by as much as 25 percent over the next 20 years. In the future, such a reduction would save billions of gallons of diesel fuel annually, or 12 percent of the fuel used (LLNL 2003bw).

LLNL is working with a consortium of research institutions and tractor manufacturers to address two major components of drag in heavy trucks: (1) the gap between the tractor and the trailer, and (2) low pressure in the trailer's wake. LLNL is developing computer simulations of various

parts of a truck's airflow. LLNL has also developed new devices for reducing aerodynamic drag that are undergoing wind tunnel testing (LLNL 2003bw).

### **O.5.3 Solid-Oxide Fuel Cell Development**

In 1999, DOE formed the Solid State Energy Conversion Alliance to accelerate the development and commercialization of fuel cells. Fuel cells are clean, quiet, efficient, and compact and generate electricity through chemical reactions instead of combustion. Fuel cells show promise to helping to reduce global warming, air pollution, and U.S. dependence on foreign oil.

LLNL is helping Solid State Energy Conversion Alliance with fuel cell development. LLNL has extensive experience in developing several types of fuel cells, including the zinc-air fuel cell, the unitized regenerative fuel cell, the direct carbon conversion fuel cell, and the solid-oxide fuel cell.

Some of the LLNL research has focused on solid-oxide fuel cell development. Solid-oxide fuel cells are particularly attractive because they have the highest efficiencies of any conventional fuel cell design and the potential to use many fuels—including gasoline and diesel—without expensive external reformers that create more volatile chemicals. Solid-oxide fuel cells can operate at high temperatures, producing high-grade waste heat, or exhaust, which can be recovered and used for other applications, such as space heating and cooling, supplying homes with hot water, and even generating electricity by spinning a gas turbine linked to the unit.

LLNL research has improved the solid-oxide fuel cell, increasing the power output of the cell. The researchers have also developed a three-cell stack prototype that generated 50 percent more power than previous development efforts (LLNL 2002bn).

LLNL is working on streamlining the solid-oxide fuel cell energy source. LLNL developed a means of eliminating an expensive process in creating the fuel to be utilized by the fuel cell when generating electricity. LLNL is continuing its efforts to improve the solid-oxide fuel cell with the goal of making it a cost-effective, environmentally friendly means of generating electricity commercially (LLNL 2002bn).

### **O.5.4 Carbon Dioxide Sequestration**

More carbon dioxide, a greenhouse gas, is making its way into our atmosphere as fossil fuels are burned and tropical lands are deforested. A strategy to reduce excess carbon dioxide in the atmosphere is to capture excess carbon dioxide and inject it underground (carbon dioxide sequestration), where it will remain sequestered from the atmosphere for thousands of years. This strategy is being used at an oil drilling platform in the North Sea, the Sleipner site. LLNL is developing criteria for identifying subsurface geologic formations that could be used for carbon dioxide sequestration (LLNL 2000c).

Starting with simulations of carbon dioxide injection at the Sleipner site, LLNL is developing a general modeling capability for analyzing carbon dioxide sequestration in geologic formations. The research has begun to identify the geochemical, hydrologic, and structural constraints on successful geologic carbon dioxide sequestration. Eventually, the research will correlate these constraints with the characteristics of potential geologic formations, rank their overall

sequestration performance based on this correlation, and thus identify optimal injection sites (LLNL 2000c).

### **O.5.5 Direct Carbon Conversion**

LLNL developed a breakthrough method for converting carbon directly into electricity without the need for steam or turbines (LLNL 2001az). Direct carbon conversion can use fuel derived from many different sources, including coal, lignite, petroleum, natural gas, and even biomass (peat, rice hulls, corn husks). If adopted on a large scale, direct carbon conversion would help to conserve fossil resources by allowing more power to be harnessed from the same amount of fuel. It would also improve the environment by substantially decreasing the generated amount of pollutants emitted into the atmosphere (per kilowatt hour of electrical energy) and decrease emissions of carbon dioxide, which contributes to global warming.

Direct carbon conversion requires a unique kind of fuel cell. A fuel cell is an electrochemical device that efficiently converts a fuel's chemical energy directly to electrical energy without burning the fuel. However, instead of using gaseous fuels, which is typically the case, the new technology uses aggregates of extremely fine carbon particles. The overall cell reaction is carbon and oxygen (from ambient air) forming carbon dioxide and electricity (LLNL 2001az).

The thermodynamic efficiency of the direct carbon conversion cell exceeds 70 percent. In contrast, conventional coal- and natural-gas-fired power plants are typically between 35 and 40 percent efficient. Combined-cycle pilot plants that burn natural gas in multistage turbines now operate at 57-percent efficiency, based on the higher heating value of the fuel. High temperature fuel cell hybrid systems (fuel cells combined with turbines) are expected to operate on natural gas at 60-percent efficiency.

In addition, a byproduct of the process is a pure stream of carbon dioxide that can be captured without incurring additional costs of collection and separation from smokestack exhausts. The stream of carbon dioxide can be stored for later use as input to another industrial process or used for oil and gas recovery through existing pipelines (see Section O.5.4, Carbon Dioxide Sequestration).

**O.6 REFERENCES**

- 40 CFR Part 247 U.S. Environmental Protection Agency (EPA), “Protection of the Environment, Comprehensive Procurement Guideline for Products Containing Recovered Materials,” *Code of Federal Regulations*, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, Revised July 1, 2003.
- 42 U.S.C. §6962 “Definitions,” Subchapter XII, Safety of Public Water Systems, Chapter 6A, Public Health Service, Title 42, The Public Health and Welfare, *United States Code*, Washington, DC, Revised.
- 42 U.S.C. §13101 et seq. “Findings and Policy”, Title 42, The Public Health and Welfare, Chapter 133, Pollution Prevention, *United States Code*, Washington, DC, 1990.
- California Health and Safety Code §25244.12-24 “Hazardous Waste Source Reduction and Management Review Act of 1989,” *California Health and Safety Code*, Division 20, Chapter 6.5, Article 11.9, Sections 25244.12-24, Sacramento, CA, 1989.
- DOE 2002s DOE, *2002 Waste Generation Trending Report for DOE Reporting Site showing Routine Waste Generation Reported for Lawrence Livermore National Laboratory for CY1993, CY1994, CY1995, CY1996, CY1997, CY1998, CY1999, FY2000, FY2001, FY2002*, U.S. Department of Energy, Washington, DC, Available online at <http://tis.eh.doe.gov/p2/wastemin/NewTrendSite.Asp?wherefrom=SITE>, 2002, Accessed May 14, 2003.
- DOE 2003d DOE, *Affirmative Procurement Results: Oakland-Lawrence Livermore National Laboratory FY 2002 Data*, U.S. Department of Energy, Washington, DC, Available online at <http://tis.eh.doe.gov/p2/apsitedata2002.cfm>, Accessed 2003.
- DOE 2003m DOE, *Executive Order 13148, Greening the Government through Leadership in Environmental Management Annual Progress Report, Appendix E, Toxic Release Inventory Reporting*, U.S. Department of Energy, Washington, DC, Available online at <http://tis.eh.doe.gov/ocpa/data/eo13148/2003.pdf>, Accessed September 3, 2003.
- DOE 2003n DOE, *Alternative Fuels Data Center Website*, U.S. Department of Energy, Washington, DC, Available online at [http://www.afdc.doe.gov/altfuel/bio\\_general.html](http://www.afdc.doe.gov/altfuel/bio_general.html), Accessed September 12, 2003.
- DOE O 430.2A DOE, *Departmental Energy and Utilities Management*, U.S. Department of Energy, Washington, DC, April 15, 2002.

|             |  |
|-------------|--|
| DOE O 450.1 | DOE, <i>Environmental Protection Program</i> , U.S. Department of Energy, Office of Environmental Protection and Guidance, Washington DC January 15, 2003.   |
| EO 13101    | Executive Order 13101, "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition," Issued on September 14, 1998 by President William J. Clinton.   |
| EO 13123    | Executive Order 13123, "Greening the Government Through Efficient Energy Management," Issued on June 3, 1999 by President William J. Clinton.  |
| EO 13148    | Executive Order 13148, "Greening the Governmental Through Leadership in Environmental Management Annual Progress Report," Issued on April 21, 2000 by President William J. Clinton.  |
| EO 13149    | Executive Order 13149, "Greening the Government Through Federal Fleet and Transportation Efficiency," Issued on April 21, 2000 by President William J. Clinton.  |
| EO 13150    | Executive Order 13150, "Federal Workforce Transportation," Issued on April 21, 2000 by President William J. Clinton.   |
| EPA 2003b   | Environmental Protection Agency (EPA), <i>Region 9 Federal Facilities, Champions of Green Government: 2001 Recipients</i> , U.S. Environmental Protection Agency, Washington, DC, Available online at <a href="http://www.epa.gov/region09/cross_pr/fedfac/01awards.html">http://www.epa.gov/region09/cross_pr/fedfac/01awards.html</a> , January 14, 2003, Accessed September 25, 2003. |
| EPA 2003e   | EPA, <i>Global Warming - Emissions Website</i> , U.S. Environmental Protection Agency, Washington, DC, Available online at <a href="http://yosemite.epa.gov/oar/globalwarming.nsf/content/emissions.html">http://yosemite.epa.gov/oar/globalwarming.nsf/content/emissions.html</a> , Last Modified on August 15, 2003, Accessed September 12, 2003.                                      |
| FEMP 2002a  | Federal Energy Management Program (FEMP), <i>Comparison Emissions Report for FY 2002 with base year FY 1990 for Lawrence Livermore National Laboratory</i> , U.S. Department of Energy, Federal Energy Management Program, Washington, DC, 2002.   |
| FEMP 2002b  | FEMP, <i>Department of Energy Management Awards: 2001 Award Winners</i> , U.S. Department of Energy, Federal Energy Management Program, Washington, DC, Available online at <a href="http://www.eere.energy.gov/femp/aboutfemp/2001_winners.html">http://www.eere.energy.gov/femp/aboutfemp/2001_winners.html</a> , Accessed September 25, 2003.   |

|             |   |
|-------------|---|
| King 2003a  | King, Karin, Email from Karin King, U.S. Department of Energy to Mary Hoganson, Tetra Tech, NUS, dated October 8, 2003, regarding the <i>Pollution Prevention Appendix</i> , 2003.  |
| King 2003b  | King, Karin, Email from Karin King, U.S. Department of Energy to Mary Hoganson, Tetra Tech, NUS, dated October 8, 2003, regarding the <i>LLNL Fleet Maintenance Shop P2 Efforts Write-Up</i> , 2003.  |
| LLNL 1997a  | Lawrence Livermore National Laboratory (LLNL), <i>LLNL FY97 Pollution Prevention Plan A Strategy for the Future</i> , UCRL-AR-127073, Lawrence Livermore National Laboratory, Livermore, CA, April 1, 1997.   |
| LLNL 2000c  | LLNL, "A Solution for Carbon Dioxide Overload," <i>Science &amp; Technology Review</i> , Lawrence Livermore National Laboratory, Livermore, CA, Available online at <a href="http://www.llnl.gov/str/Johnson.html">http://www.llnl.gov/str/Johnson.html</a> [December 2000], Accessed September 18, 2003. |
| LLNL 2001q  | LLNL, <i>LLNL Report on Pollution Prevention and Energy Efficiency Leadership Goals</i> , UCRL-AR-142203, Lawrence Livermore National Laboratory, Livermore, CA, February 2001.   |
| LLNL 2001r  | LLNL, <i>Environment Safety and Health Manual, ES&amp;H Management, Management Requirements, Construction Subcontractor Environment, Safety and Health Program</i> , Vols. 1-2, Document 2.4, UCRL-MA-133867, Lawrence Livermore National Laboratory, Livermore, CA, April 1, 2001.                       |
| LLNL 2001s  | LLNL, <i>Mitigation Monitoring Program at Lawrence Livermore National Laboratory, FY98</i> , UCRL-AR-123511-98, Lawrence Livermore National Laboratory, Livermore, CA, November 2001.   |
| LLNL 2001az | LLNL, "Turning Carbon Directly into Electricity," <i>Science &amp; Technology Review</i> , Lawrence Livermore National Laboratory, Livermore, CA, June 2001.  |
| LLNL 2002ag | LLNL, <i>Non-Hazardous Waste Diversion at LLNL</i> , UCRL-7B-120696, Rev. 7, Lawrence Livermore National Laboratory, Livermore, CA, 2002.   |
| LLNL 2002bi | LLNL, <i>FY02 - Annual In-House Energy Management Report</i> , Lawrence Livermore National Laboratory, Livermore, CA, November 15, 2002.  |
| LLNL 2002bn | LLNL, "Solid-Oxide Fuel Cells Stack Up to Efficient, Clean Power," <i>Science &amp; Technology Review</i> , UCRL-52000-02-9, Lawrence Livermore National Laboratory, September 2002.  |

|             |  |
|-------------|--|
| LLNL 2002cc | LLNL, <i>2001 Site Annual Environmental Report (SAER) for LLNL</i> , UCRL-50027-01, Lawrence Livermore National Laboratory, Livermore, CA, September 1, 2002.  |
| LLNL 2003l  | LLNL, <i>2002 Site Annual Environmental Report (SAER)</i> , UCRL-50027-02, Lawrence Livermore National Laboratory, Livermore, CA, August 29, 2003.   |
| LLNL 2003bk | LLNL, Letter from Jacky Angell, LLNL Manager, Mechanical Utilities Division, to Nellie Tibbs-Greer, Office of Federal Energy Management Program, dated May 16, 2003, regarding <i>LLNL-TSMP Award Nomination Package, Nomination for Organizational-Energy Efficient Mobility Award</i> , Lawrence Livermore National Laboratory, Livermore, CA, 2003. |
| LLNL 2003bl | LLNL, Email from Katharine Gabor, LLNL, to Mary Hoganson, Tetra Tech, Inc., dated September 12, 2003, regarding <i>Award Nominations for the 2001 DOE Oakland P2 Awards</i> , Lawrence Livermore National Laboratory, Livermore, CA, 2003.   |
| LLNL 2003bm | LLNL, Email from Katharine Gabor, to Mary Hoganson, Tetra Tech NUS, dated September 11, 2003, regarding <i>ROI Projects Listed in the 2000 SAER</i> , Lawrence Livermore National Laboratory, Livermore, CA, 2003.   |
| LLNL 2003bn | LLNL, Email from Katharine Gabor, LLNL, to Mary Hoganson, Tetra Tech NUS, dated September 11, 2003, regarding <i>ROI Proposals 2001</i> , Lawrence Livermore National Laboratory, Livermore, CA, 2003.   |
| LLNL 2003bo | LLNL, Email from Katharine Gabor, LLNL, to Mary Hoganson, Tetra Tech, NUS, dated September 11, 2003, regarding <i>GEM Pilot Project 2002</i> , Lawrence Livermore National Laboratory, Livermore, CA, 2003.  |
| LLNL 2003bp | LLNL, Reviewer comment on the LLNL Draft SWEIS, Appendix O, Lawrence Livermore National Laboratory, Livermore, CA, October 8, 2003.  |
| LLNL 2003bq | LLNL, Letter from C. Susi Jackson, LLNL, to Karen King, U.S. Department of Energy, Oakland Operations Office, dated August 22, 2003, regarding <i>Transmittal of LLNL Hazardous Waste Management Progress Report for CY2002</i> , Lawrence Livermore National Laboratory, Livermore, CA, 2003.   |
| LLNL 2003br | LLNL, Email from Beverlee Morales, LLNL, to Mary Hoganson, Tetra Tech, Inc., dated September 24, 2003, regarding <i>Affirmative Procurement Data Question on Vehicle Products</i> , Lawrence Livermore National Laboratory, Livermore, CA, 2003.   |

|                  |  |
|------------------|--|
| LLNL 2003bs      | LLNL, Email from D. Nguyen, LLNL, to Karen King, U.S. Department of Energy, Oakland Operations Office, dated September 11, 2003, regarding the <i>Addendum to Model Office Building Contract</i> , Lawrence Livermore National Laboratory, Livermore, CA, 2003.  |
| LLNL 2003bt      | LLNL, "Flexibly Fueled Storage Tank Brings Hydrogen-Powered Cars Closer to Reality," <i>Science &amp; Technology Review</i> , Lawrence Livermore National Laboratory, Livermore, CA, June 2003.  |
| LLNL 2003bu      | LLNL, Personal communication from R. Schonfeld, LLNL, to Karen King, U.S. Department of Energy, Oakland Operations Office, dated September 30, 2003, regarding <i>LLNL Plant Engineering Facility and Maintenance Management Division</i> , Lawrence Livermore National Laboratory, Livermore, CA, 2003.             |
| LLNL 2003bv      | LLNL, <i>Pollution Prevention Efforts Earn EPA Awards</i> , Lawrence Livermore National Laboratory, Chemistry and Materials Science, Livermore, CA, Available online at <a href="http://www-cms.gov/s-t/pollution_prev.htm">http://www-cms.gov/s-t/pollution_prev.htm</a> s, Accessed September 24, 2003.            |
| LLNL 2003bw      | LLNL, "Reducing Aerodynamic Drag," <i>Science &amp; Technology Review</i> , UCRL-52000-03-5, Lawrence Livermore National Laboratory, Livermore, CA, May 2003.  |
| LLNL 2003bx      | LLNL, Email from K. Wilson, LLNL, to Mary Hoganson, Tetra Tech, Inc., dated September 23, 2003, regarding <i>Affirmative Procurement</i> , Lawrence Livermore National Laboratory, Livermore, CA, 2003.  |
| LLNL/EPD 2003    | Lawrence Livermore National Laboratory /Environmental Protection Department (LLNL/EPD), <i>About the EPD</i> , Lawrence Livermore National Laboratory, Livermore, CA, Available online at <a href="http://www.llnl.gov/epd.about_epd.html">http://www.llnl.gov/epd.about_epd.html</a> , Accessed September 25, 2003. |
| OTT 2001         | Office of Transportation Technologies (OTT), <i>United States Department of Energy Compliance Strategy for EO 13149</i> , U.S. Department of Energy, Office of Transportation Technologies, June 2001.   |
| Richardson 1999b | Richardson, Bill, Memorandum from Bill Richardson, Secretary of Energy to the Heads of Department Elements, dated November 12, 1999, regarding <i>Pollution Prevention and Energy Efficiency Leadership Goals for FY2000 and Beyond</i> , U.S. Department of Energy, Washington DC, November 12, 1999.               |